Korea Heat & Fluid Technology

Steam jet ejector
Application for steam ejector
Thermo-compressor
Chilling unit
Ejector condenser
Desuperheater
Water ejector & others

KHFT

• Steam jet Ejector

Steam jet ejector is a device for producing vacuum which is achieved by using a high pressure motive steam. The primary advantages of steam jet ejector are simplicity of operation, no mechanical drive and has no moving parts.

Typically steam jet ejector has three parts ; the jet nozzle(2), the suction chamber (3) and the diffuser (4, 5, 6). The figure 1 illustrates basic operation principle of the steam jet ejector.

The high pressure steam is supplied in steam chest (1), and expanded through jet nozzle (Converging & diverging nozzle causes the velocity up to mach number 3.0 or 4.0) and them motive stream injected into a suction chamber.
The suction chamber has the lowest static pressure (approximately equivalent to the suction pressure Ps). The suction fluid enters into the suction chamber(3) and is mixed with motive steam in the diffuser inlet (4). Kinetic energy of motive steam is transferred to the suction fluid through diffuser throat (5).
Motive steam & suction fluid mixtures are converted the velocity energy to the pressure energy (recompressed to the discharge pressure Pd) through diffuser outlet (6).

Korea Heat & Fluid Tchnology research has produced numerous improvements in steam jet ejector design and test results.
Right figure illustrates suction capacity which calculated by computer at entrance of diffuser. Suction capacity at right figure is 55kg/hr which corresponds to minimum value to the curve. Sometimes there is no minimum value, in this case, eddy current occurs and suction capacity decreases suddenly (By professor Ueda).

Nomenclature

1. Steam chest
2. Jet nozzle
3. Suction chamber
4. Diffuser inlet
5. Diffuser throat
6. Diffuser outlet

Design Factor

Pm	: Motive pressure
Ps	: Suction pressure
Pd	: Discharge pressure
Mm	: Motive steam flow rate
MS	: Suction flow rate
α = Pm/Ps	: Expansion ratio
κ = Ps/Pd	: Compression ratio
u = Ms/Mm	: Flow ratio

Benefits of steam Jet ejector

- Simple Structure and trouble free.
- Low maintenance cost and long life.
- No mechanical drive & no moving parts.
- Low installation cost.
- No limit to the capacity.
- Made of any material.
- Explosion proof construction

Figure 1
Basic structure & flow model of Steam Jet Ejector

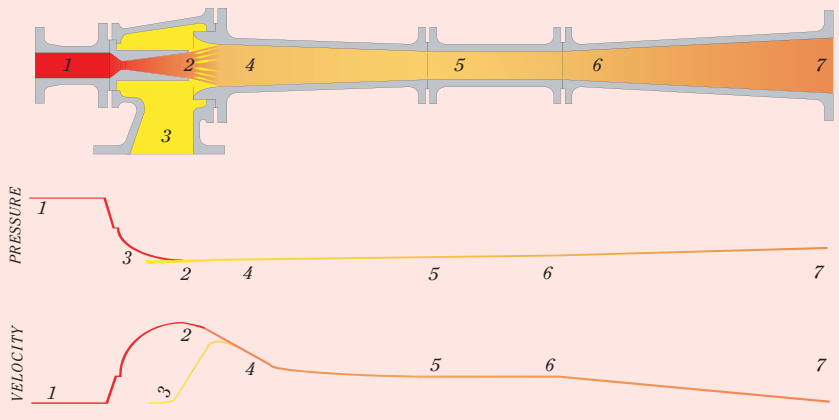
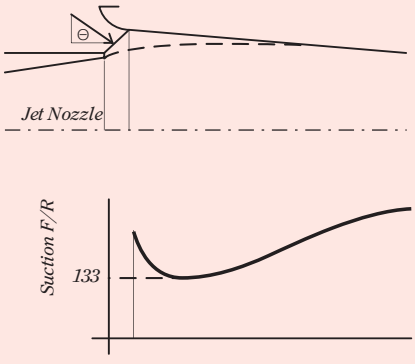


Figure 2
Flow Model of suction flow rate

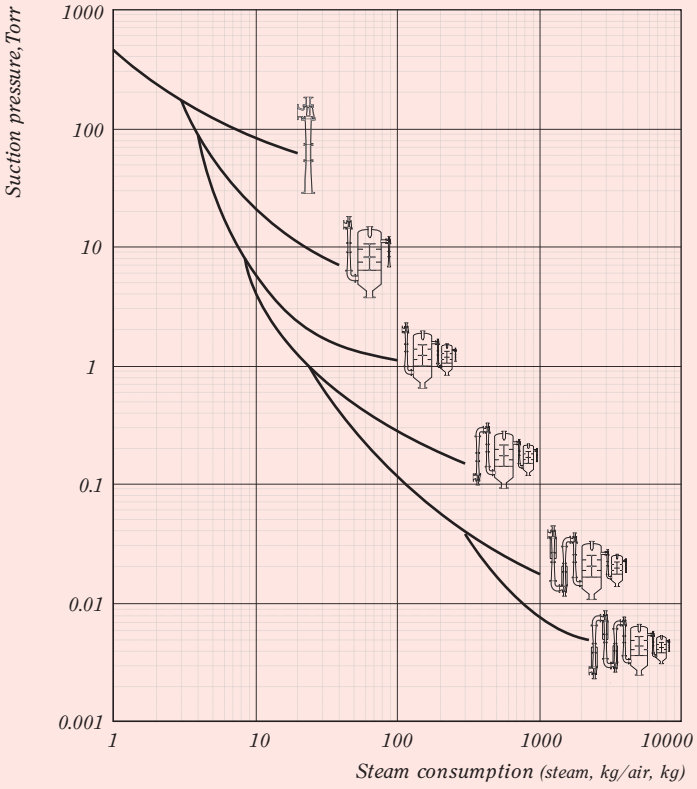


Types & designations of jet ejectors

Suction medium \ Motive medium		Liquid jet	Steam jet	Gas jet
Liquid ejector		Liquid jet liquid ejector	Steam jet liquid ejector	Gas jet liquid ejector
Gas ejector	Ventilator	Liquid jet ventilator	Steam jet ventilator	Gas jet ventilator
	Compressor	Liquid jet compressor	Steam jet compressor	Gas jet compressor
	Vacuum ejector	Liquid jet vacuum ejector	Steam jet vacuum ejector	Gas jet vacuum ejector
Solid		Liquid jet solid ejector	Steam jet solid ejector	Gas jet liquid ejector

* The terms of jet ejectors laid down accoding to DIN24290.

Typical ejector stages & relative steam consumptions



Steam jet ejectors are used in field

- Steam power plants :
  Vacuum pump for surface condenser
- Petrochemical :
  Distillation, deodorization plants
- Synthetic fiber :
  Polymerization of polyester fiber
- Food : vacuum dryer
- Paper : Thermo Compressor
- Ship building :
  Crude oil stripping pump
- LPG Terminal : jet condenser
- Steel industry :
  Degassing unit for RH, DH, TD, LD
- Environmental : Thermo Compressor
- Pharmaceutical : Frozen dryer

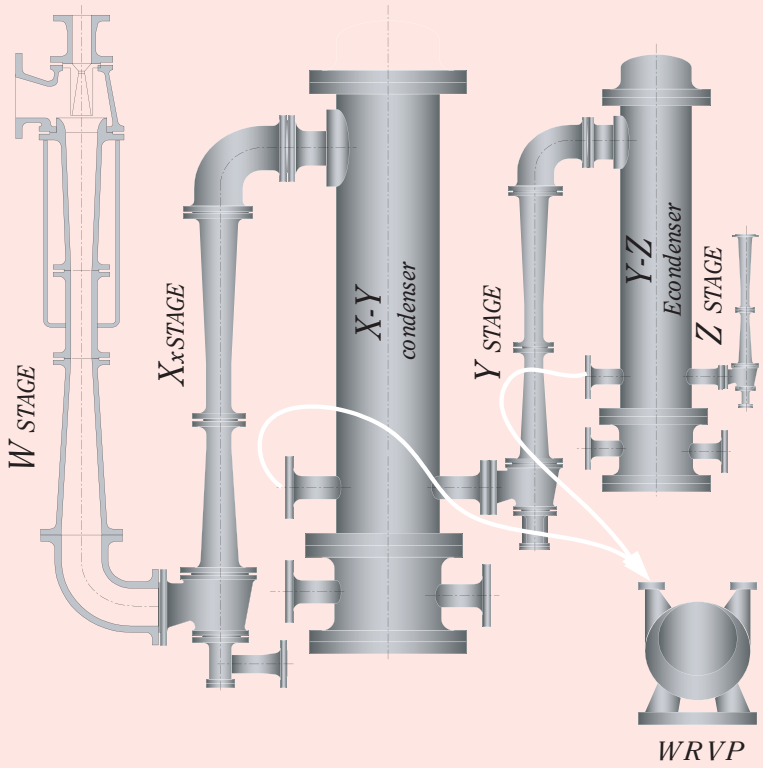
Motive Fluid

- Steam 〈 $2.0kg/cm^2$ abs
- Air 〈 $1.0kg/cm^2$ abs
- Water 〈 $3.0kg/cm^2$ abs
- LPG 〈 $4.0kg/cm^2$ abs
- Compressed gas

Korea Heat & Fluid Technology's is the leading company for innovative, high performance of steam ejector for process industries. The design, production, test facilities create an environment for the manufacture of customer satisfaction and creative the value of customer.

· Steam jet Ejector

Designations for ejector assembly

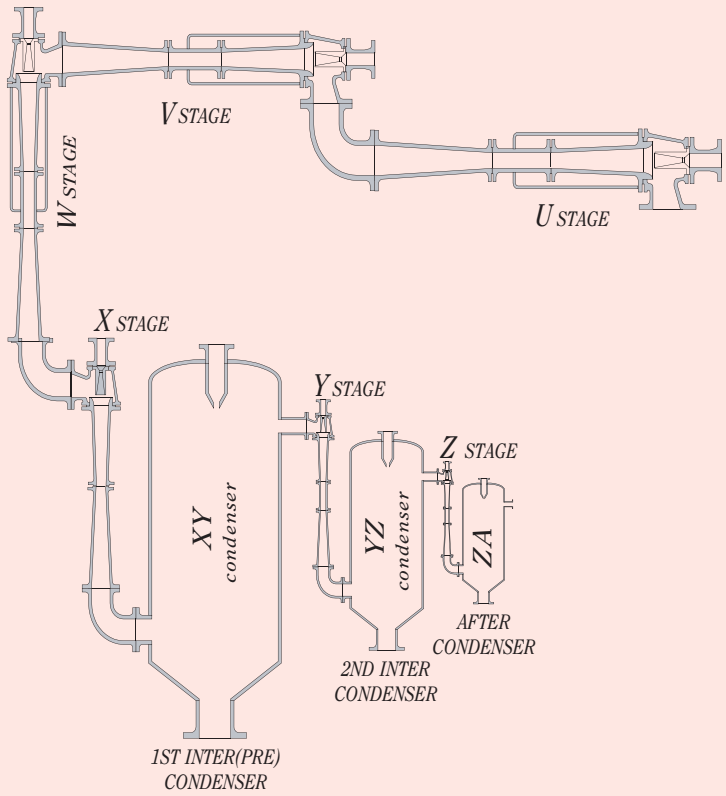


A typical steam jet ejector system Consistence of one or more steam ejector assemblies with associated ejector condensers arranged to condense vapor discharged from previous ejector stage assemblies. Left figure illustrates four stage steam jet ejector with inter/after condenser, two stage steam ejector with intercondenser & water ring vacuum pumps.

Designation for ejector system

U stage	: 4th booster
V stage	: 3rd booster
W stage	: 2nd booster
X stage	: 1st booster
Y stage	: 1st ejector
Z stage	: 2nd ejector
XY condenser	: 1st inter condenser
YZ condenser	: 2nd inter condenser
ZA condenser	: after condenser
WRVP	: Water ring vacuum pump

Common type of ejector & condenser stage



Definitions of terms

절대압력	: *Absolute pressure*
흡입압력	: *Suction pressure*
배출압력	: *Discharge pressure*
무부하압력	: *Blind suction pressure*
정상운전	: *Stable operation*
흡입가스온도	: *Suction gas temperature*
건조공기	: *Dry air*
환산공기량	: *Air equivalent*
설계유량	: *Design point*
구동압력	: *Motive pressure*
증기소모량	: *Steam consumption*
시동용 이젝터	: *Evacuation ejector*
소음기	: *Silencer*
분자량	: *Molecular weight*
증기압축기	: *Thermocompressor*
부스터	: *Booster*

Contact point

Tel : (82-55) 337-8678

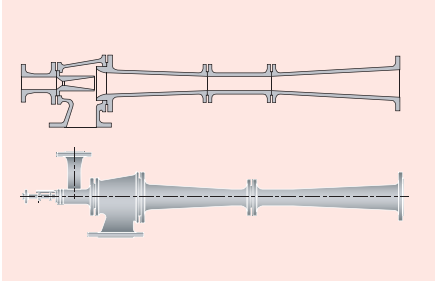
Fax : (82-55) 337-8679

E-mail : ok01910@kornet.net

http://khft.koreasme.com

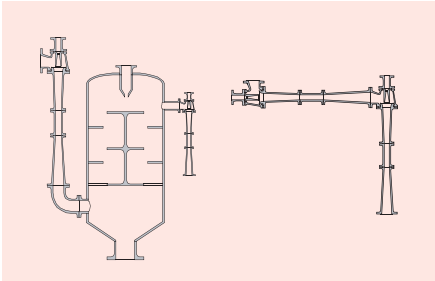
Single stage steam ejector

A single stage steam ejector is used for ultimate suction pressure 10kPa (75Torr) and normal suction pressure up to 15kPa (120Torr).
Discharge pressure is mostly equivalent to the atmospheric pressure, for exhausting the following methods are employed.
(1) up to silencer and muffler, (2) sealed in hot well or seal pot with pressurized vent, (3) after condenser.



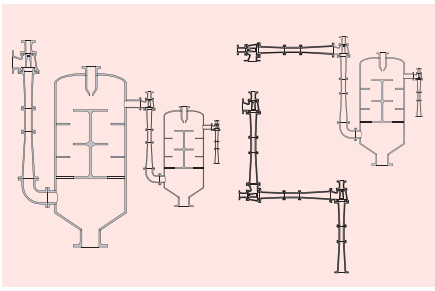
Two stage steam ejector

Two stage steam ejectors are used for suction pressure 20kPa (150Torr) or below, and the ultimate suction pressure is up to 2kPa (15Torr).
Two stage steam ejectors include three types ; (1) two stage non-condensing ejector : small capacity, (2) two stage ejector with barometric inter condenser : continuous operation and steam consumption per capacity is lowest, (3) two stage ejector with surface inter condenser : eliminates water contamination and product recovery system.



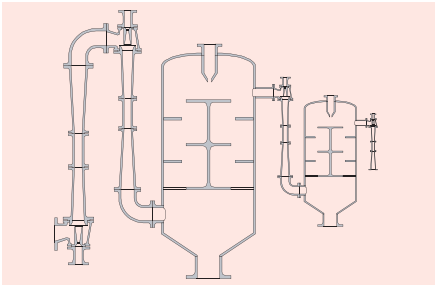
Three stage steam ejector

Three stage steam ejectors are used for suction pressure 5kPa (38Torr) or below, and the ultimate suction pressure is up to 0.5kPa (3.8Torr).
Three stage steam ejectors are include three types ; (1) three stage non-condensing ejector : small capacity and intermittent service, (2) two stage booster and 3rd ejector with inter condenser : continuous and high vacuum range, (3) three stage ejector with two inter condenser : achieve maximum steam economy. Impossible to condense gas at pressure too low to permit condensation (suction pressure below 25Torr), with available cooling water. This case consist of vary large 1st stage (booster), which is always designed to compress the vapors to the condensable pressure.



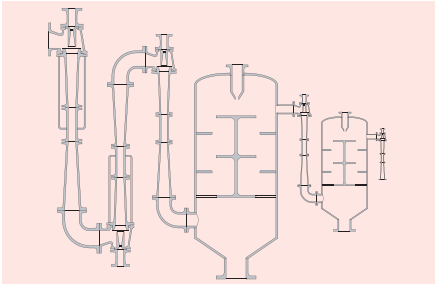
Four stage steam ejector

Four stage steam ejector is designed for high vacuum range, suction pressure 0.5kPa (3.8Torr) or below, and ultimate suction pressure in up to 0.07kPa (0.5Torr). The suction pressure is below 4.6Torr, steam saturation temperature is sufficiently below 0℃ to freeze moisture in the suction gas and motive steam, thus the forming of ice between jet nozzle and diffuser inlet. The avoid of the ice formation, required steam jacket the jet nozzle and diffuser.



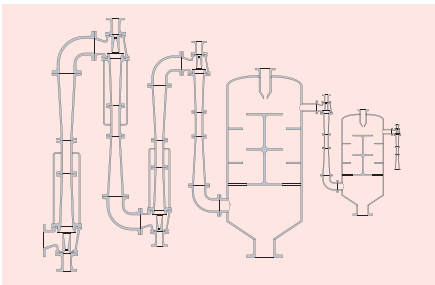
5th stage steam ejector

Five stage and six stage steam ejector are commonly used for special process and space research field, and vacuum metallurgy process such as RH-OB degassing unit at POSCO.
Suction pressure range of five stage steam ejector is 0.01kPa (0.75Torr) to 0.013kPa (0.1Torr).



6th stage steam ejector

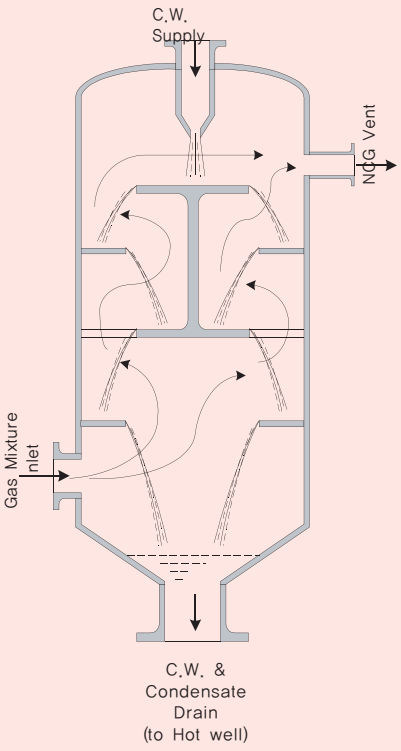
Suction pressure range of six stage steam ejector is below 0.013kPa (0.1Torr).



• Steam jet Ejector

Direct contact or barometric condenser

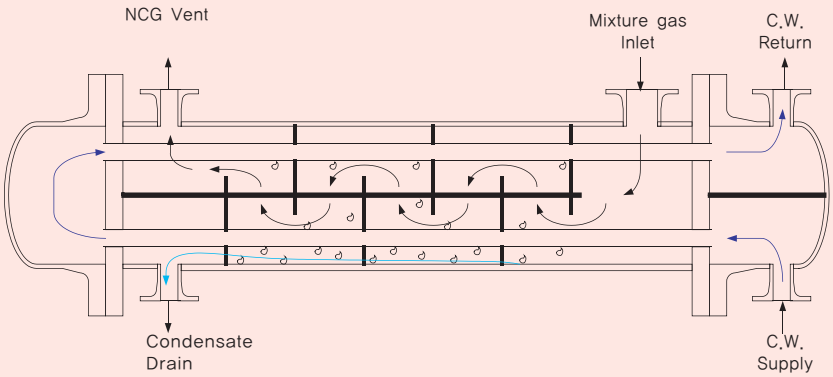
Direct contact condensers are constructed to effect condensation of steam and other condensable vapors by means of direct contact with the cooling water. There are two principle types, of counter flow and parallel flow of condensable vapor and cooling water.



Barometric condenser

Shell and tube (surface) condenser

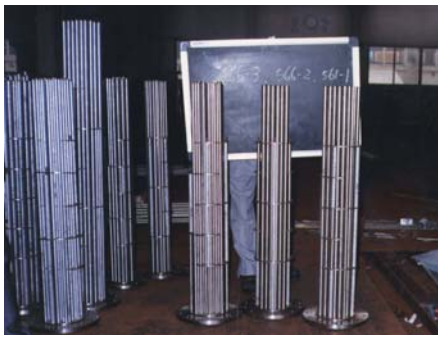
Shell & tube type condenser do not mix process vapor and cooling water, so there is no contamination of the cooling water.
Below figure illustrations of shell & tube type heat exchanger is specially adapted for condensing on ether the shell and tube side. If the fouling is minor, shell side condensing is better, else condensing vapor is extremely fouled, so, tube side condensation is better for easy mechanical cleaning Tube bundles are adapted fixed type, u–tube type & floating head type tube sheet.



Shell & tuve type Condenser

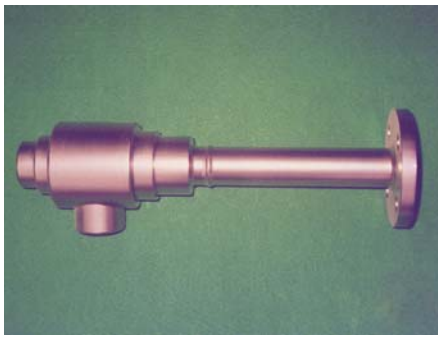
· Application for Steam Ejector

Condenser channel pit-up tests



Tube bundle assembly & pit-up tests

Condenser assembly & Performance test



Steam & water jet ejector unit assembly

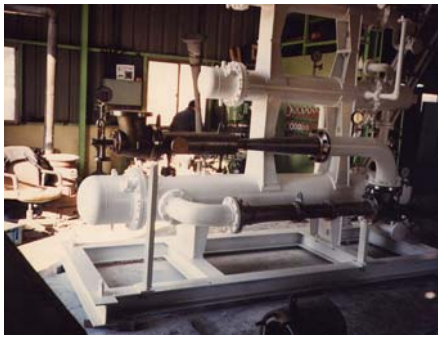
Steam & water jet ejectors wait for pit-up tests

Ejector & condensers assembly

Steam jet booster with steam jet vacuum unit for crystallizer package system : K titanium

Two elements 2 stage steam jet ejector with surface condensers for power plant : Co-generation plant

Barometric condenser with 3-booster stage for steel treatment process(RH-OB system) degassing unit



4 stage steam jet vacuum system for KCR plant : K petrochemical

5 & 6 stage steam jet degassing unit for steel making : P iron & steel co.

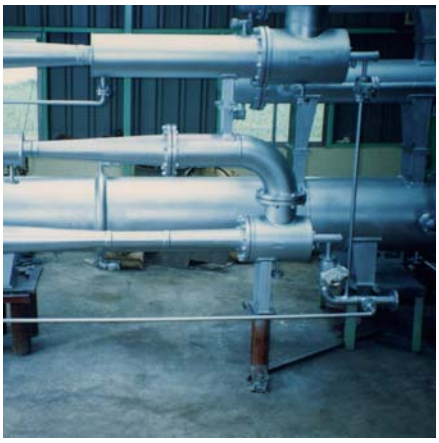
• Application for Steam Ejector

Steam jet ejector with full jacket for EG & air vent unit : T synthetic febers (Polymerization process)

2 stage steam jet vacuum system with pre-condenser for crude oil refineries : TPI phase III

Two stage steam jet vacuum system of power plant for surface condenser

Vacuum system for cargo pump turbine (VLCC) : MHI Nagasaki ship-yard



5 stage steam jet vacuum system for energy saving plants : NL co-generation

2 stage steam jet vacuum system for alchol projet : LG chemical

4 stage steam jet vacuum system for film evaporator : K petrochemical

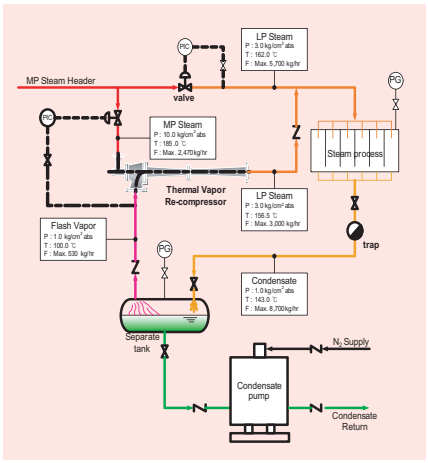
3 stage steam jet vacuum unit with barometric condenser for 3AA gas recovery plants : LG chemical

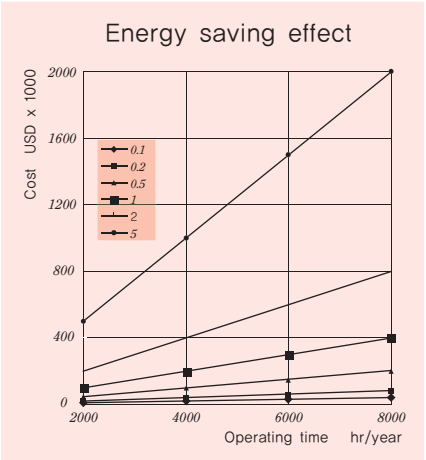
Steam jet vacoom system for Phenol & BPA : LG Petrochmical

· Thermo-Compressor

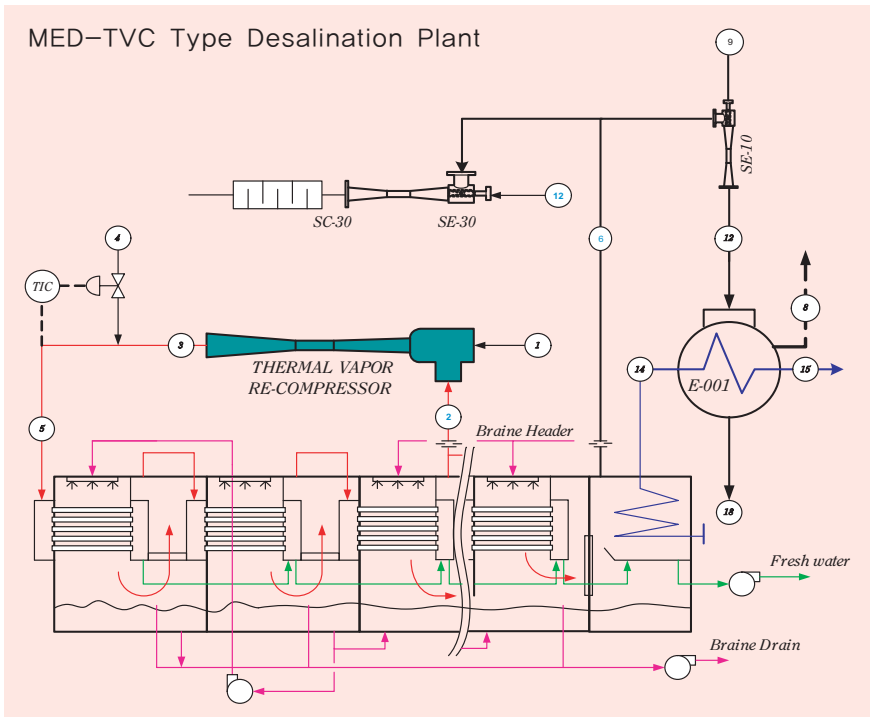
Thermo compressor is a type of ejector, which utilites a high pressure steam jet to entrain a low pressure steam, and mix the two fluid flow and discharge at the middle pressure.
Thermo compressors are used in the chemical process, paper, petroleum and other industries to circulate steam and condensate flash vapor.

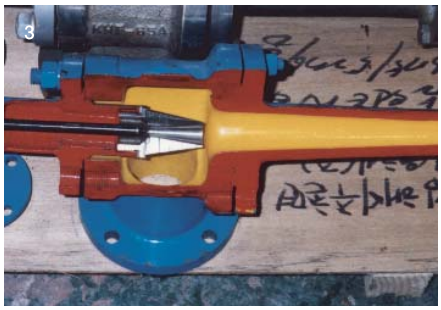
KHFT's thermo compressors include three types ;
(1) fixed single nozzle type : no control, (2) spindle controlled single nozzle type : suction and discharge pressure vary greatly, requiring large compensating motive steam flow rate, (3) fixed multi nozzle type : large size and high performance.





▲ Flash vapor re-compression and recirculation thermo compressor for the process condensate drain system : KPA BPA process





1. Measurement of flash vapor flow rate and temperature.

2. Thermo compressor for 4 stage multi effect desalination pilot plant : KIMM

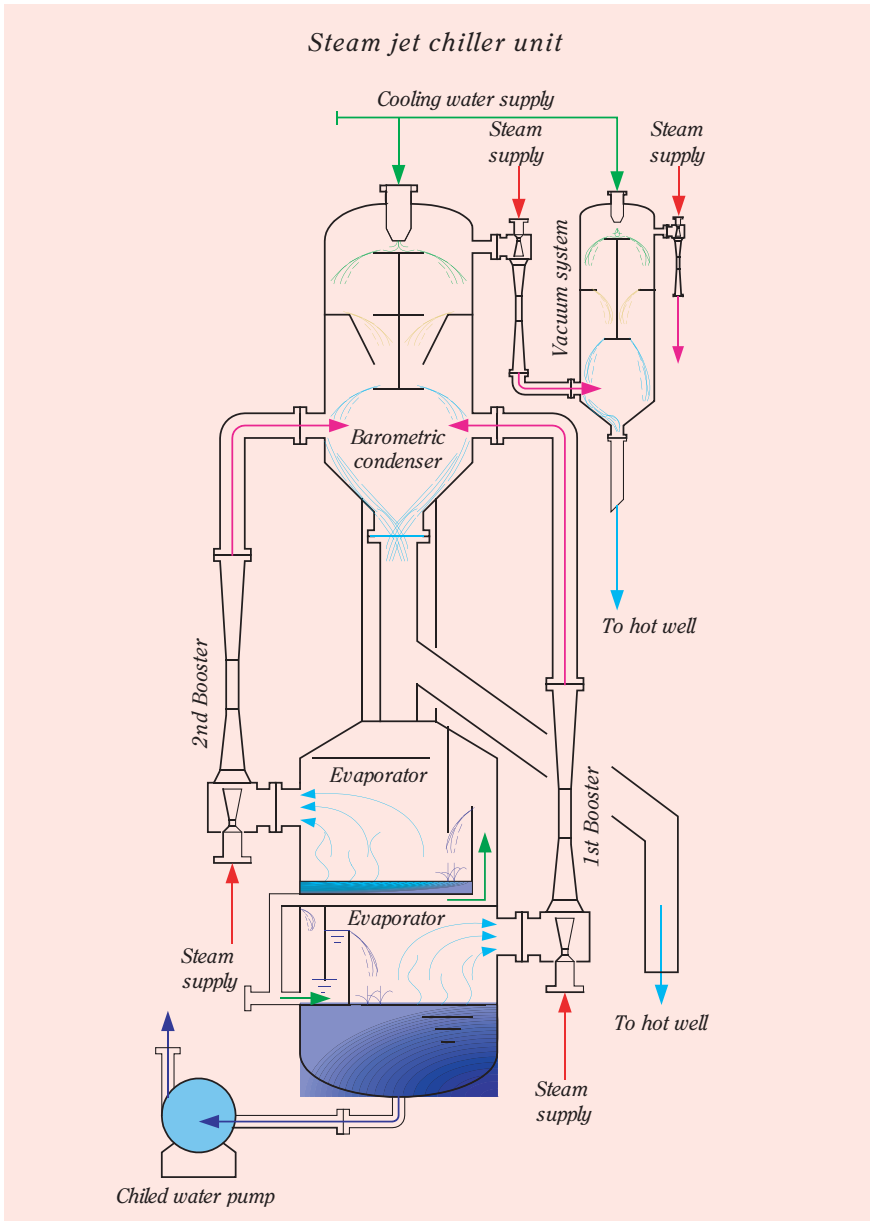
3. Spindle controlled single nozzle type thermo compressor

• Steam Ejector Chiller Unit

KHFT’ s steam ejector chiller unit is a reliable vacuum flash cooling system. This system is application in the paper, food processing, pharmaceutical industries, chemical and petroleum field.
A steam jet refrigeration system consists of an evaporator or flash tank, two or one booster, a booster condenser (barometric or surface condenser) and a two stage steam jet vacuum ejector

*Stean jet chiller unit*의 특징

- Simple and low maintenance cost.
- Low installation cost.
- Explosion proof construction.
- Low operating pressure.
- No limit to the capacity.
- Explosion proof construction.
- High reliable system.
- Eliminate hazardous refrigerants.
- De-aerate in cooling water.

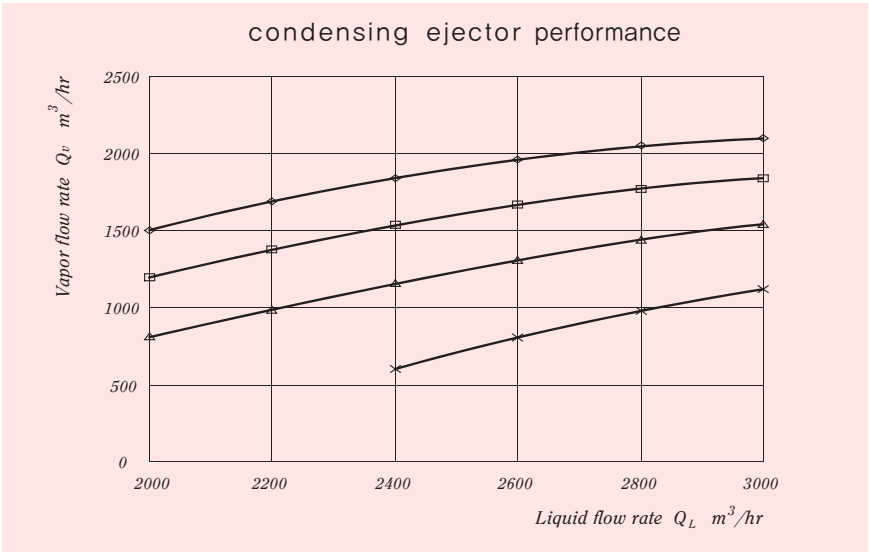


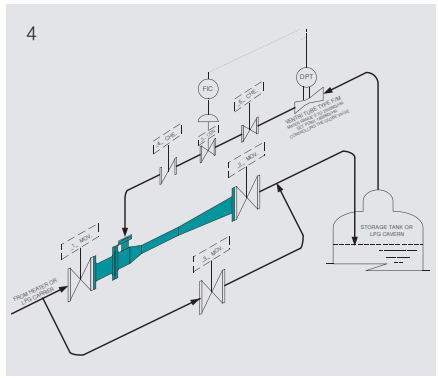
1. Booser for 1000RT chiller unit.

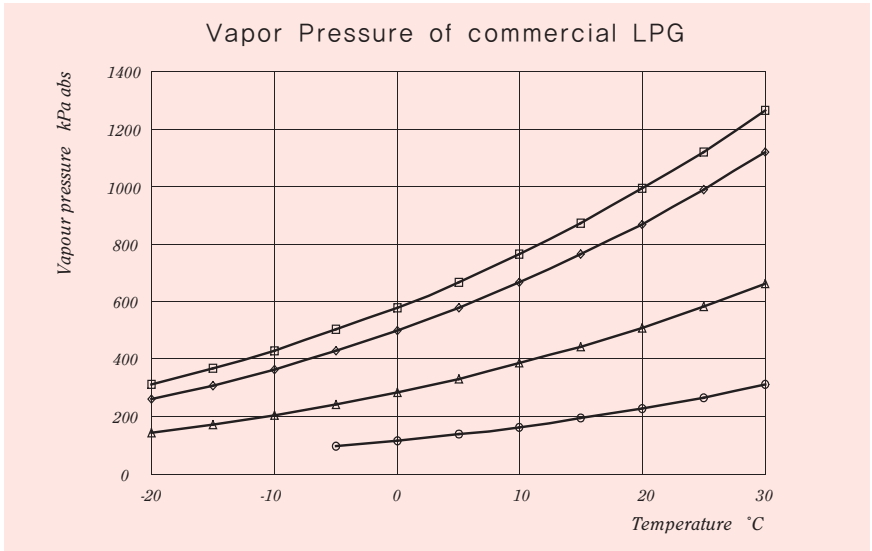
2. Evaporizer : PEMAX Project

· Condensing Ejector

When unloading liquefied propane gas (LPG) ships at very high flow rate into the LPG storage cavern, excessive in-cavity pressure rise due to vapor generation at high rate.
Condensing ejector used to cope with it and make easier unloading operations. The purpose of the condensing ejector is to condense of the vapor phase from the storage cavern, utilize into the liquid propane stream being unloading from LPG carrier ship to the cavern.
The cold energy of the LPG is used in the ejector condenser for suction and condense the vapor from cavern.







1. Mixing chamber of liquid propane & vapor
2. Condensing ejector : LG Caltex
3. LPG storage carvern : SK gas
4. P&ID for condensing ejector

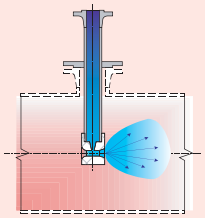
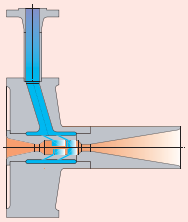
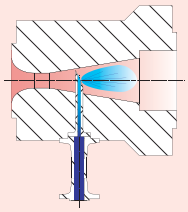
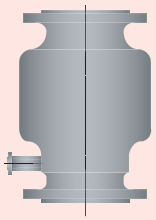
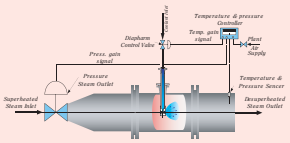
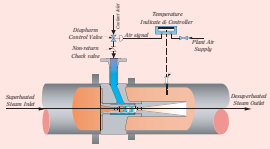
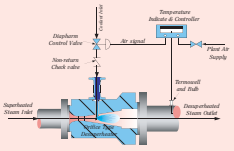
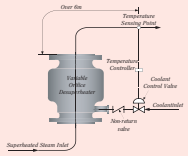
· Desuper Heater

De-super heater is requirements for steam supplying units with limited operating temperatures such as steam tracing system, auxiliaries equipments, heat exchanger and dump system at LNG carrier and power plant .

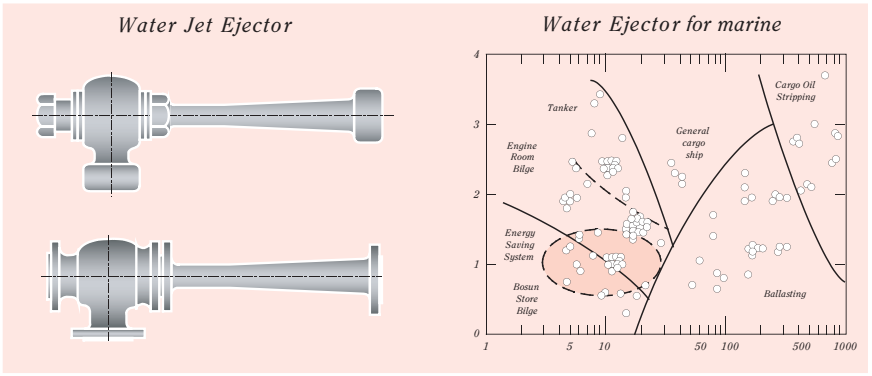
Super heated steam is an excellent source of energy transfer, but for certain applications saturated steam or steam with some super heated. The most economical way of controlled super heated steam temperature is the direct contact of the cooling water injection.

The injection cooling water, intimately mixed with super heated steam and attracts energy from the super heated steam and vaporizes.

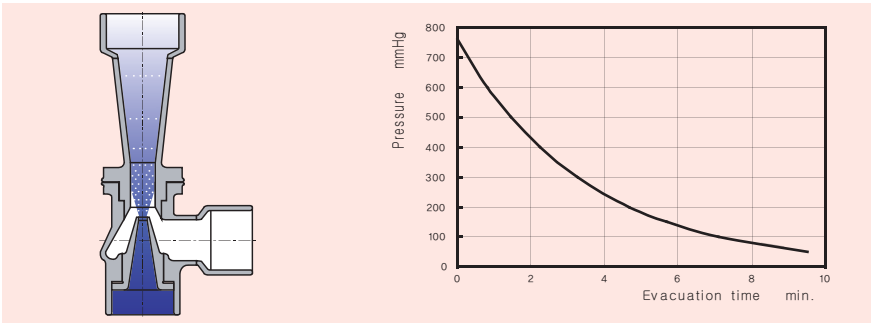
The result is a low temperature (approximately saturate temperature or setting temperature) of super heated steam.

Structure						
Type	*Single nozzle Spray type*	*Multi nozzle Spray type*	*Ejector Mixing Type*	*Venturi tube Mixing Type*	*Venturi II Type*	*Variable Orifice Type*
Arrangement of system	 Typical Mechanical Spray Desuperheater installaiton with pressure & temperature controller		 Typical installation of Venturi Type Desuperheater		 Automatically controled schematic diagram of Orafice type desuperheater	 Typical Variable Orifice Desuperheater installation with temperature controllerand coolant control valve
Turn-down Ratio	*Max. 3:1*	*Max. 10:1*	*Max. 15:1*	*Max. 20:1*	*Max. 5:1*	*Max. 40:1*
Installation	*Hori./Vert.*	*Hori./Vert.*	*Hori./Vert.*	*Hori./Vert.*	*Hori./Vert.*	*Vertical*
TemperatureAccuracy	*Sat. +20˚C or more*	*Sat. +10˚C or more*	*Sat. +6˚C or more*	*Sat. +5˚C or more*	*Sat. +7˚C or more*	*Sat. +3˚C or more*
Temp.Detecting Distance	*15m or more*	*12m or more*	*20m or more*	*10m or more*	*12m or more*	*6m or more*
Cooling Water Pressure	*Steam +7bar or more*	*Steam +5bar or more*	*Steam +0bar or more*	*Steam +0bar or more*	*Steam +1bar or more*	*Steam +3bar or more*
Steam Piping Size	*6" or more*	*8" or more*	*6" or more*	*4" or more*	*3" or less*	*3" or more*
Application	*Load, Temp. - Small vari.* *Press. drop - Small* *• Condenser dump* *• Turbine dump* *• Process steam*		*Load, Temp. - Large vri.* *Press. drop - Very small* *• Turbine dump* *• Process steam*		*Load, Temp. - Small* *Press. drop - Middle* *• Turbine dump* *• Process steam*	*Load-Large variation* *Temp.-Rapid respons* *Press drop - middle* *• Important process*

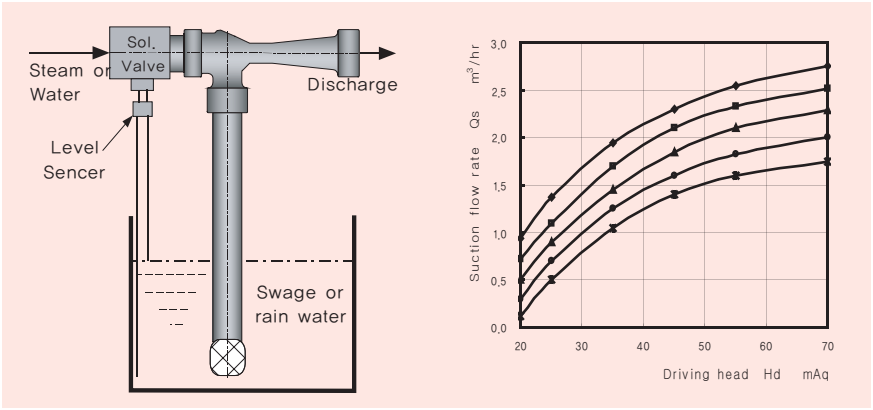
· Other Applications



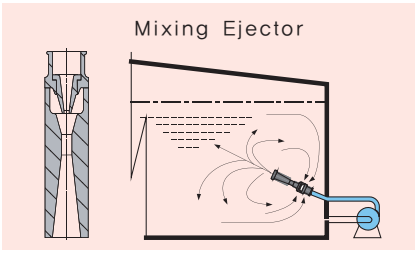
▲ Liquid jet ejectors are widely uesd in the marine of ballast pumps, bilge pumps, in tank mixer, heater and priming for large water pumps,



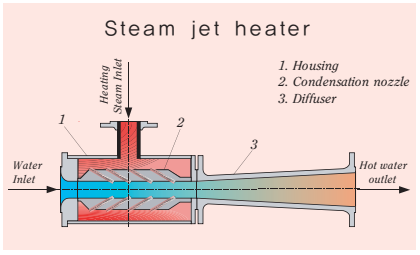
▲ Water jet vacuum ejectors are designed for evacuating siphon lines, priming of column and circulation pumps.



▲ Water jet ejectors are used to pumping out sumps (pit, tanks, etc.).



▲ Liquid jet mixers are jet pumps to batch mixing of oil, tank belending of oil or process utility.



▲ Steam jet heaters are used in the direct connection water and steam lines for noiseless heating of the melt industry, warm water for pickling and wash.

1. Water jet ejectors
2. Water jet solids pumps
3. Liquid jet air ejector : honam petrochemical
4. Water jet sluge drain pumps

· Design & Manufacturing

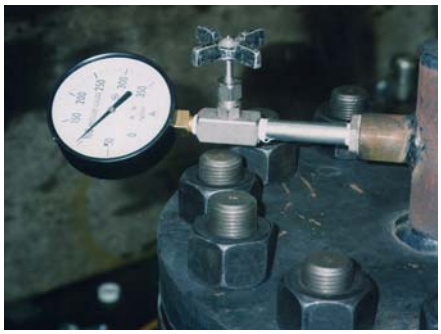
Design & drawing

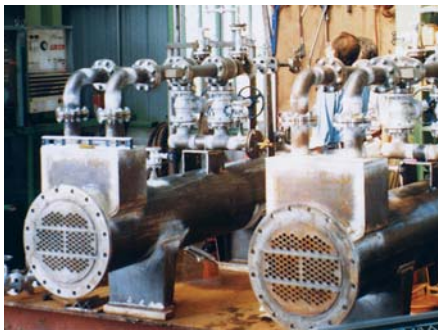
▲ Using CAD system for design engineers can share information about design data.

Technical support

▲ Technical and appilcation are handled by engineers who are directly involved with the design and developement of vacuum system

Quality control





▲ Qulity management activity system

QA VISION

Customer satisfaction

Create the value of customer

QA STRATEGY

Best quality : R&D knowledge infra

Best service : Activity with ownership

Best system : ISO9001 : 2001

Performance test

Shop test

▲ Performance test for Two elements water jet eductor

▲ Four stage steam ejector with inter after condenser shop performance test

Design pressure : 4.0Torr,

Suction flow rate : 70.0kg/hr (Air eq.)

Field test

▲ Five stage steam ejector with inter after condensers for field test

Design pressure : 0.5Torr,

Suction flow rate : 6.5kg/hr (Air eq.)

Reach & development

Our R&D center has been developing the high performance of steam jet ejector and application system to be requested on the industrial field in the future.

▲ We have developed the design and manufacturing technology of four effect type desalination system ; joint KIMM

▲ Technology & engineering for Enviromental, energy and future life
Multi effect waste water treatment system and waste oil treatment system.

Brief history

1983	*Successfully developement of Water jet eductor*
1985	*Successfully developement of Steam jet Air ejector*
1991	*Development of the Water jet eductor CAD program*
1992	*Development of the Steam jet Air ejector CAD program*
1992	*Company established under Korea Heat & Fluid Industries*
1995	*Development of the Shell & tube type CAD program*
1995	*Company established under Korea heat & fluid Co., Ltd.*
1996	*Established Seoul office*
1997	*Successfully developement of Desuper heater*
1998	*Achived ISO-9001 by "ABS-QE"*
2001	*Company name changed Korea heat & fluid technology*
2005	*Move head office from samjung to juchon*
2005	*Achived ISO-9001 : 2000 by "KMAi-KAB"*